

Possibility of a Muon-Electron Conversion Experiment at LANSCE/MaRIE

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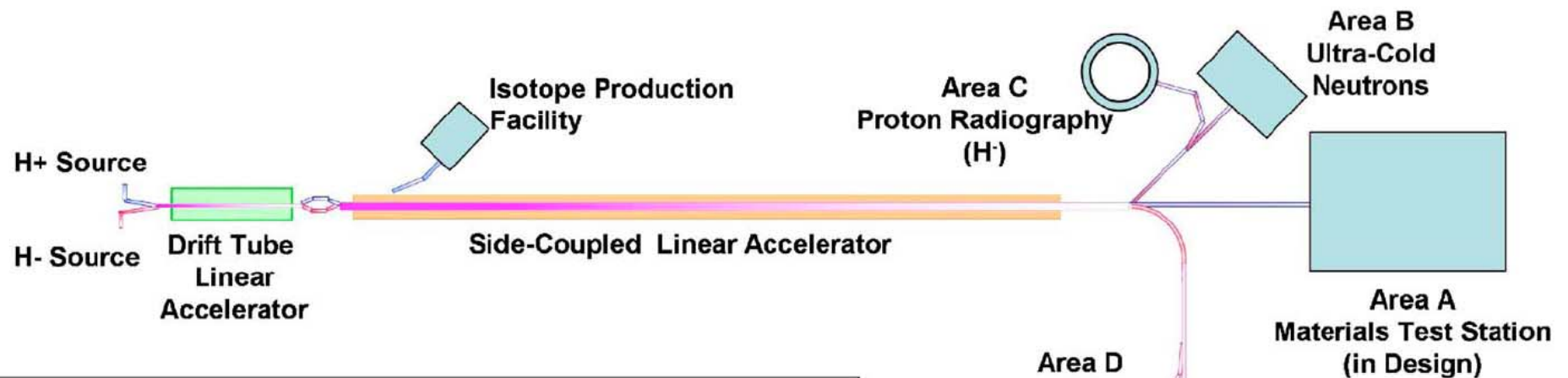
Possibility at LANSCE

Los Alamos Neutron Science Center



Possibility at LANSCE

- LANSCE Accelerator - 800 MeV, ~ 1 MW linac
 - One of the highest power linacs in the world
 - Very flexible operation possible
- Can a MELC/MECO/Mu2e/COMET type experiment be performed at LANSCE? Can it do better at LANSCE?
 - Can we achieve the necessary pulse structure and extinction?
 - Is such an experiment compatible with existing and planned operations?
 - Can we produce enough pions/muons?
- Preliminary answer: yes to all



Proton Linear Accelerator

Two ion sources produce H⁺ and H⁻ beams
 0.75 MeV to 100 MeV Drift Tube linac
 100 MeV to 800 MeV Side-Coupled linac

Isotope Production Facility

Medical radioisotope production using 100 MeV protons

Weapons Neutron Research Facility

High-energy neutrons and protons for nuclear science and applications

Lujan Center

Moderated neutrons for neutron scattering and nuclear science

Proton Radiography Facility

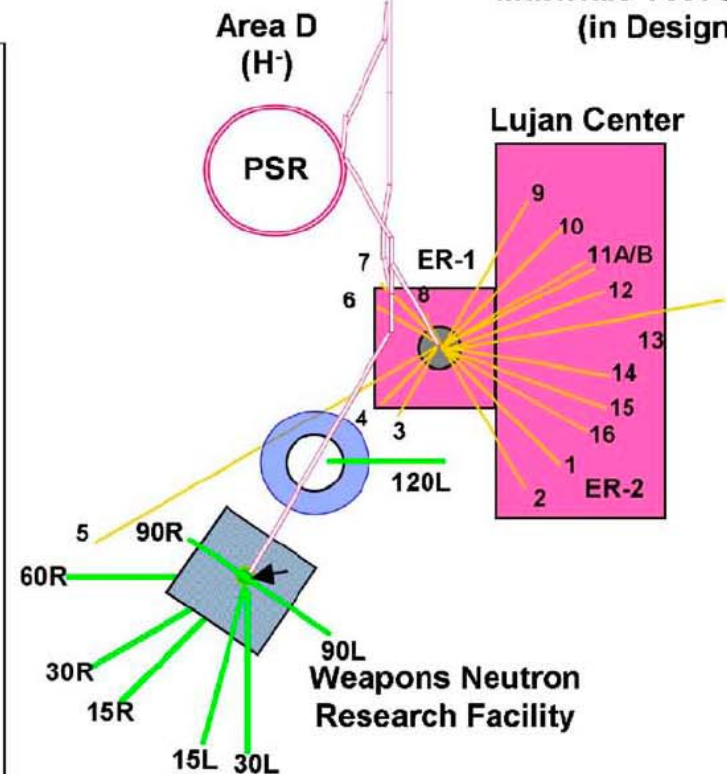
Pulsed proton beam for static and dynamic radiography

Materials Test Station

High-power fast neutron irradiation of reactor fuels and components

Ultra Cold Neutron Facility

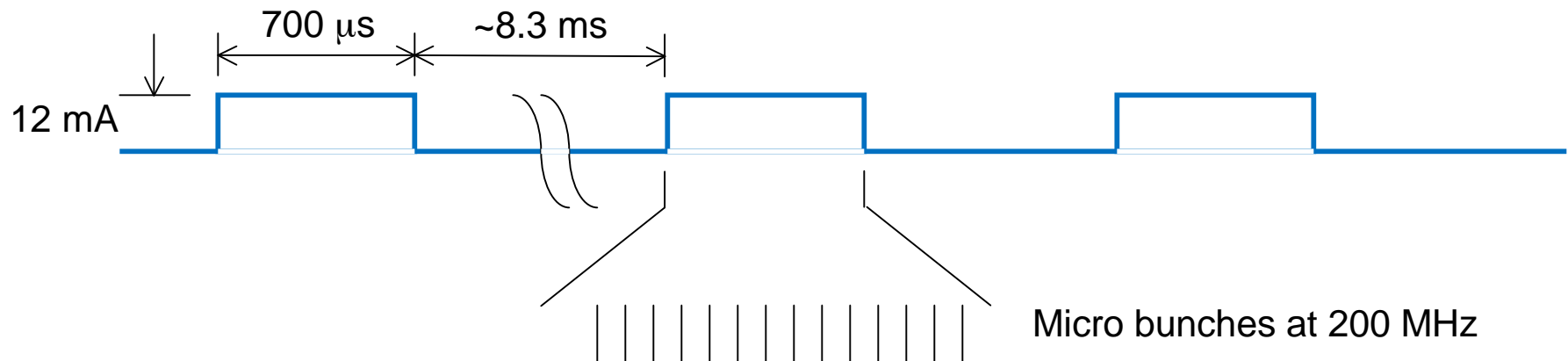
Fundamental physics experiments with UCN

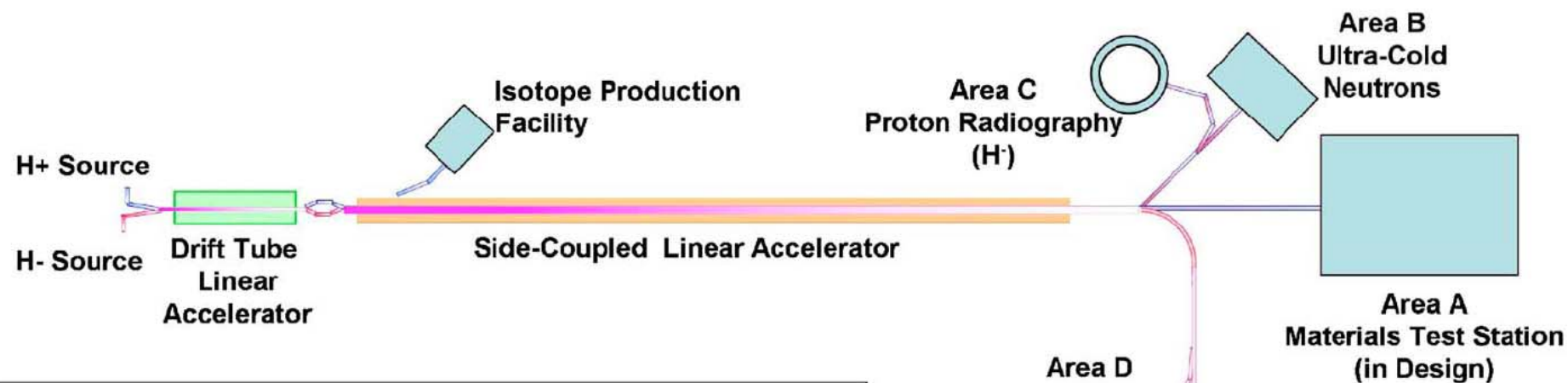


LANSCe Accelerator

Selected Parameters and Pulse Structure

- Can accelerate both H^+ and H^- simultaneously (but total particle current is RF power limited).
- 700 μs long macropulses with 12mA (17 mA for H^+) current averaged over microbunch strings at 120 Hz
 - Average current = $12\text{mA} \times 700\text{ }\mu s \times 120\text{ Hz} = 1\text{ mA}$
 - Average power = $1\text{ mA} \times 800\text{ MeV} = 0.8\text{ MW}$
 - Duty factor = 8.4 %
- Microbunches at 200 MHz
 - H^+ and H^- micro bunches go to RF cavity 180 degree out of phase to each other
- 700 μs long macropulses can be chopped at front end to pulse structure that suits the experimenter's need





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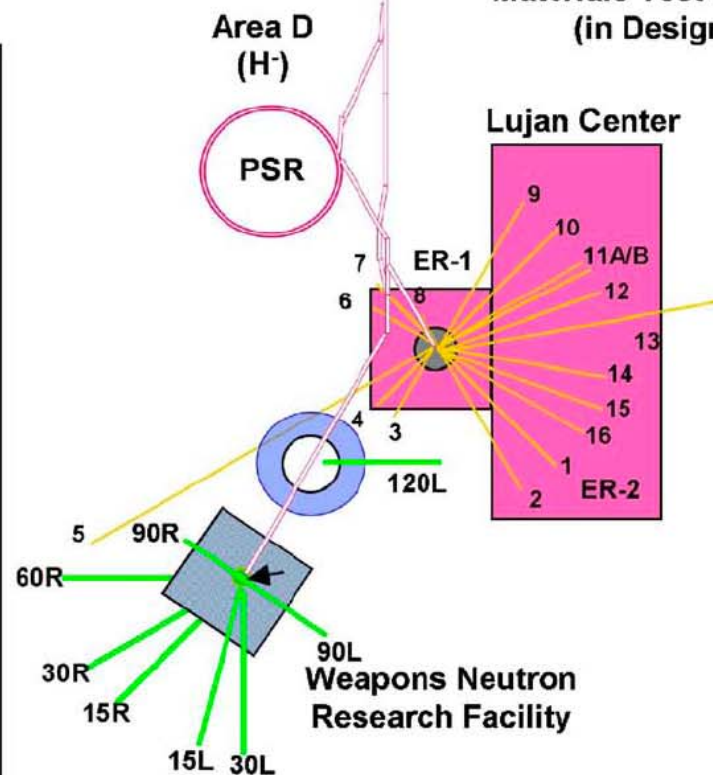
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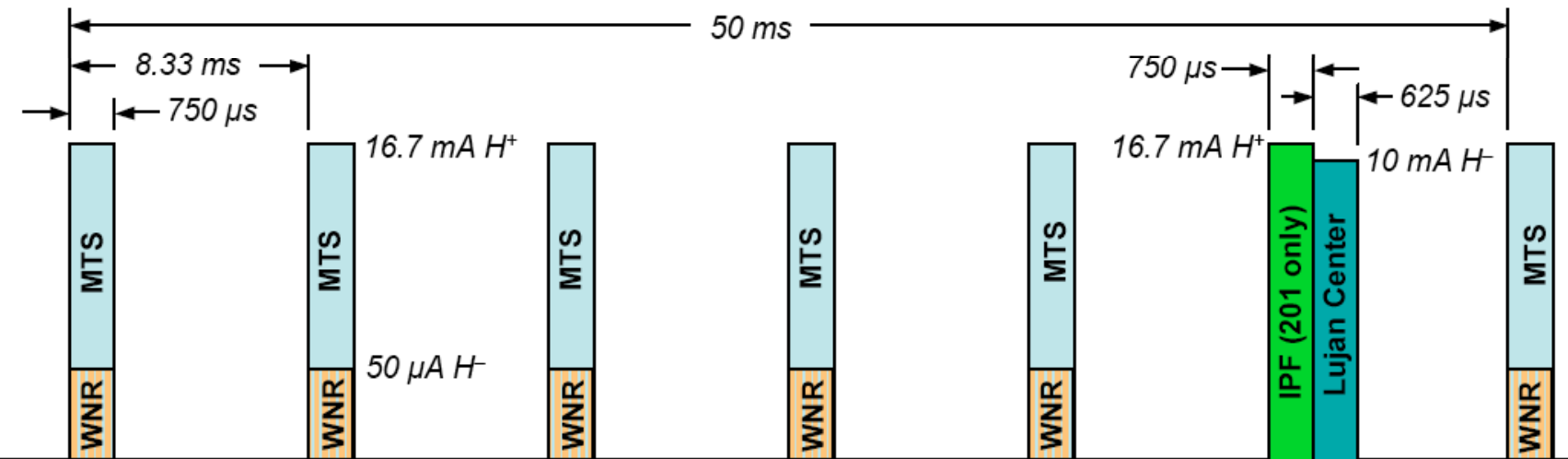
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Target	Time-Averaged Current (μA)
Materials Test Station (MTS)	1250
Isotope Production Facility (IPF)	250
Lujan Center	125
Weapons Neutron Research facility (WNR)	5
Proton Radiography (PRad)	on demand
Ultra-Cold Neutron Source (UCN)	on demand

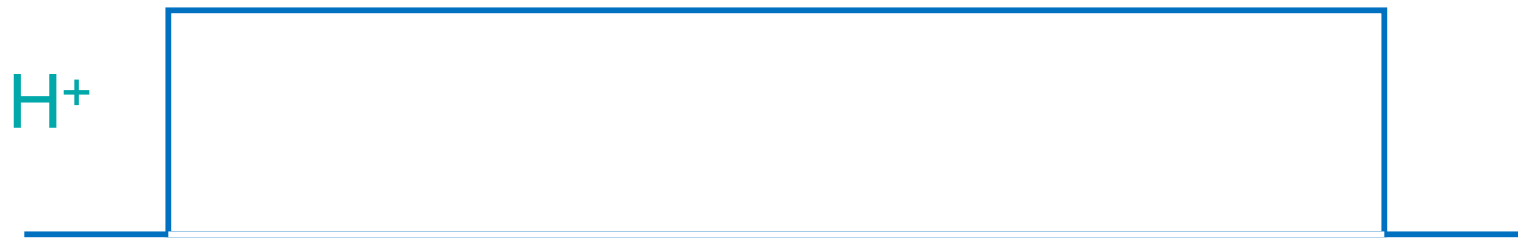
Possible Sites/Accelerator Operation Modes

- Assumptions: LANSCE-R and MTS in Area A

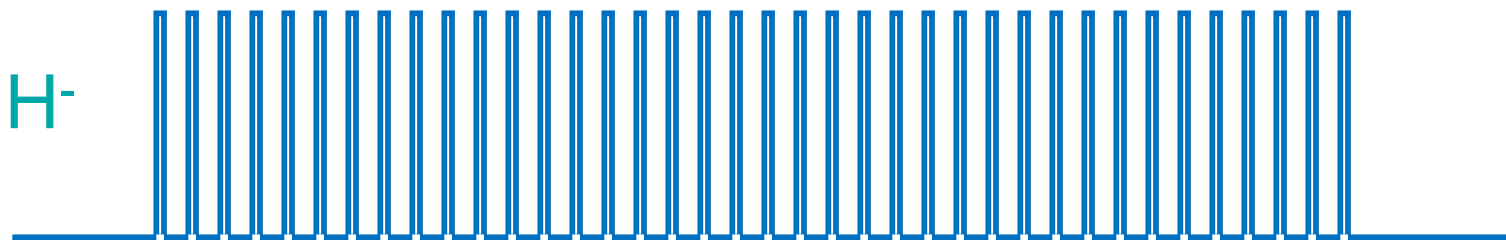
	Operating scenario	Location of experiment	Estimated duty-cycle average current	Comments
A	100 Hz parasitic operation with the H ⁺ beam for the MTS facility. Accelerate H ⁻ linac beam bunches of 100ns length spaced 1-2 μ s in the same linac macropulses as the H ⁺ beam.	Area A	$\sim 40\text{-}80\ \mu\text{A}$ with present macropulse $\sim 60\text{-}130\ \mu\text{A}$ with present macropulse	Use the switching kicker magnet that currently is used to steer H- macropulses to Area B and C. Use existing bending magnet LXBM01 to diver beam from line X. From there new beamline to Area A is required. Negligible linac power bill.
B	Same parasitic mode and average current as Scenario A above, but use RIKI plus an existing dc magnet to rout the H ⁻ beam into line E.	New facility at the end of line E	$\sim 40\text{-}80\ \mu\text{A}$ with present macropulse $\sim 60\text{-}130\ \mu\text{A}$ with present macropulse	Requires new building and utilities, etc. at the end of line E, but there is no conflict with Lujan. Negligible linac power bill.

One Possible Mode of Running Parasitically to MTS at Area A

- MTS macro pulse: H^+ , 17 mA peak current



- Mu-e conversion experiment macro pulse: H^- , 12 mA peak current, chopped to 100 ns pulse every 1-2 μs

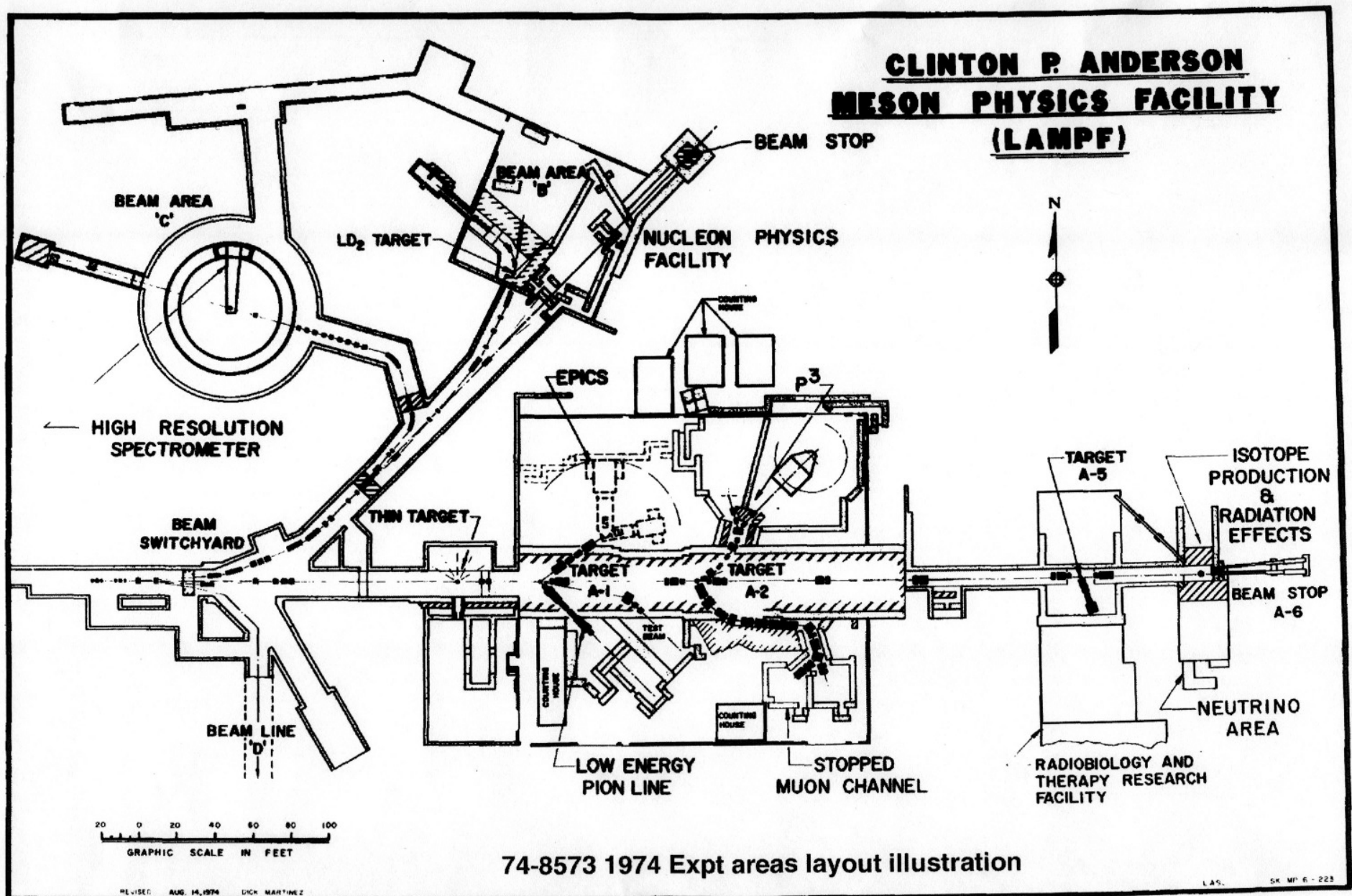


Can get up to ~ 60kW

Materials Test Station (MTS) for Advanced Fuel Cycle Research

- A project currently under design, to be located in Area A
- 1 MW spallation neutron source for materials testing for Global Nuclear Energy Partnership
- To be funded by DOE, Office of Science, Fusion Energy Science
- Projected timeline
 - CD-1/CD-2a/CD-3a June 2008
 - CD-2b January 2009
 - CD-3b July 2009
 - CD-4 March 2012

Areas A, B, and C

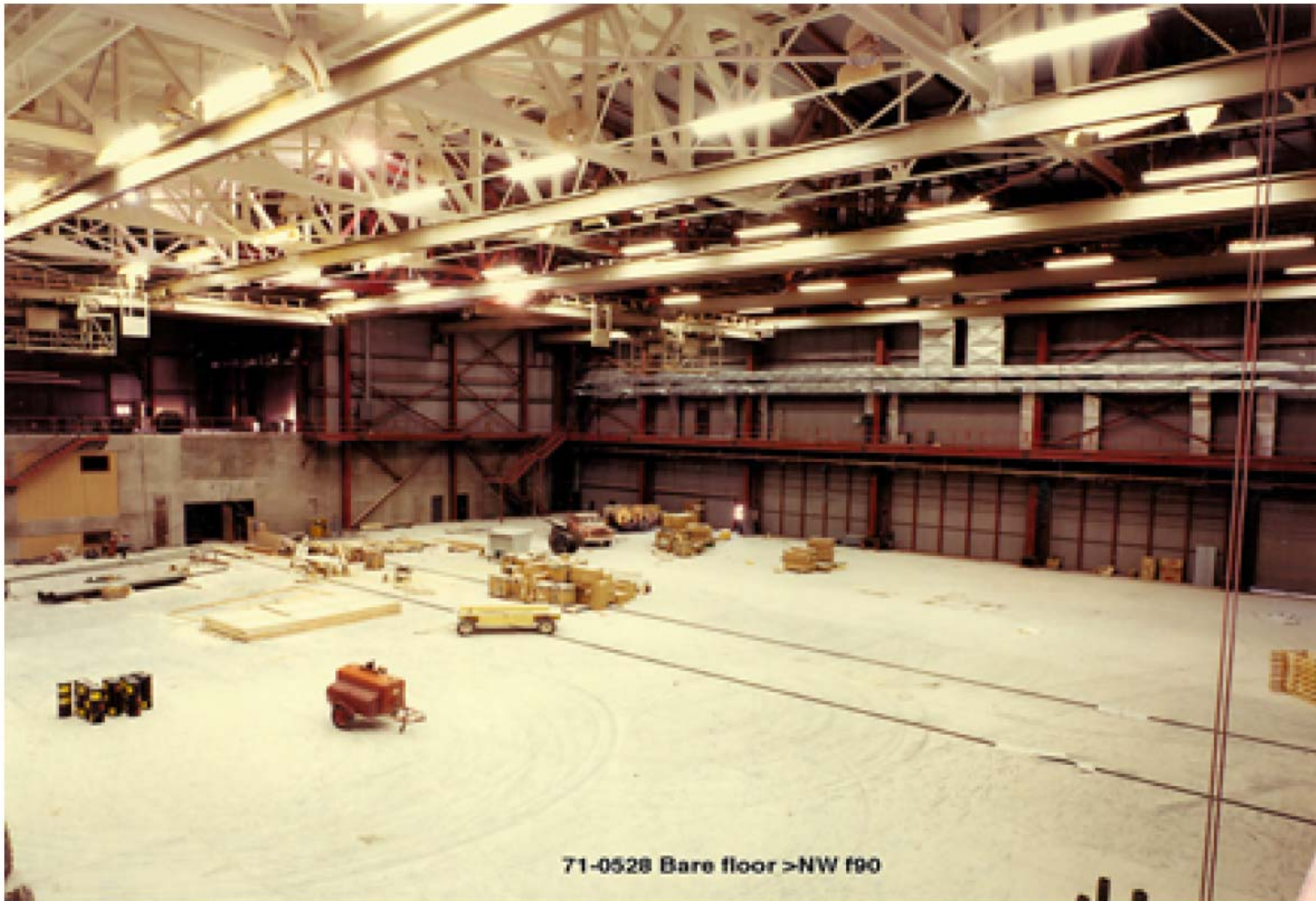


Area A: now



73-2967 Steel around A-1
w/igt comp >SE 190

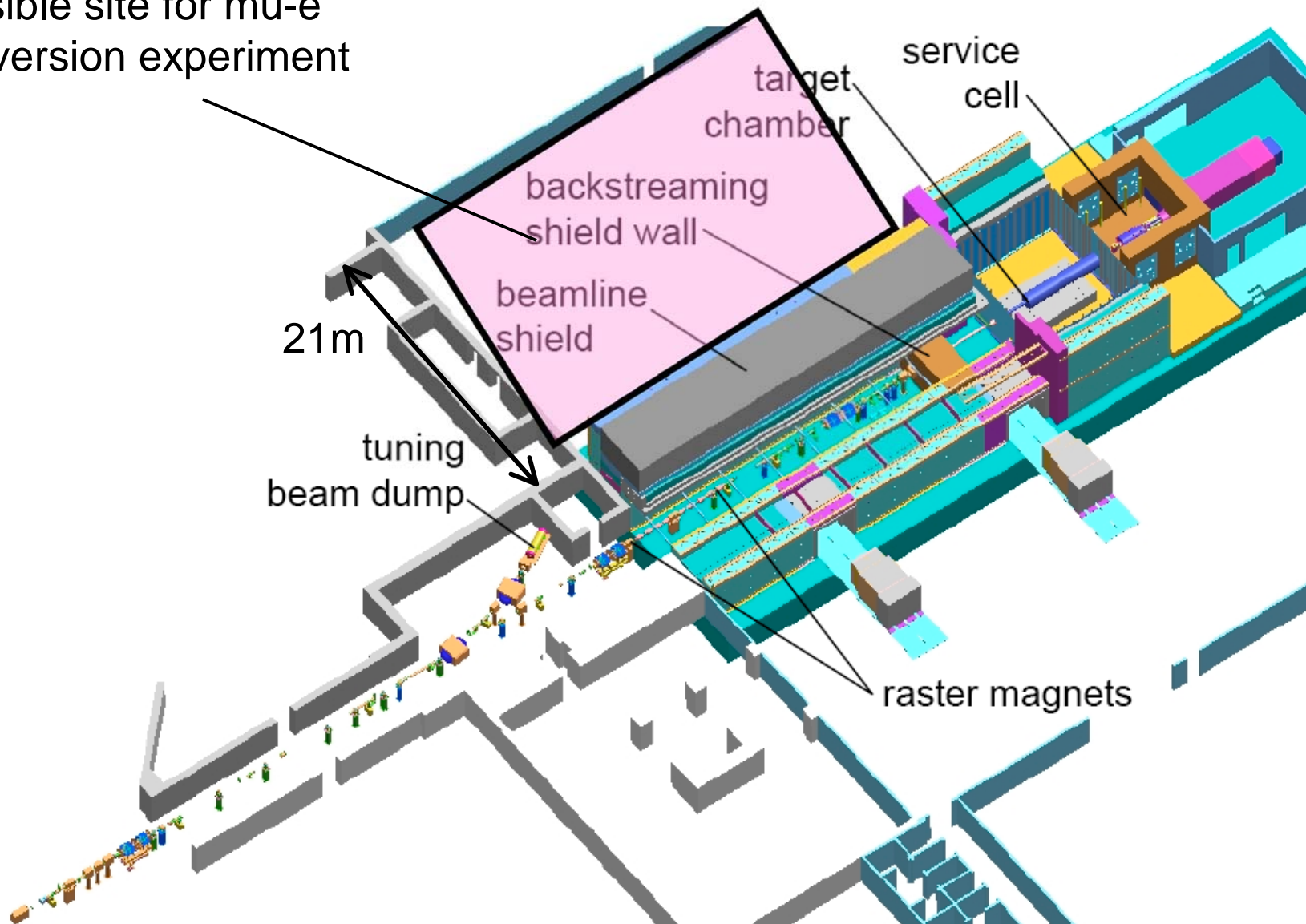
Area A: 1971



71-0528 Bare floor >NW 190

Mu-e conversion experiment in Area A with MTS

Possible site for mu-e
Conversion experiment



Muon energy distribution

(Taken from MECO document)

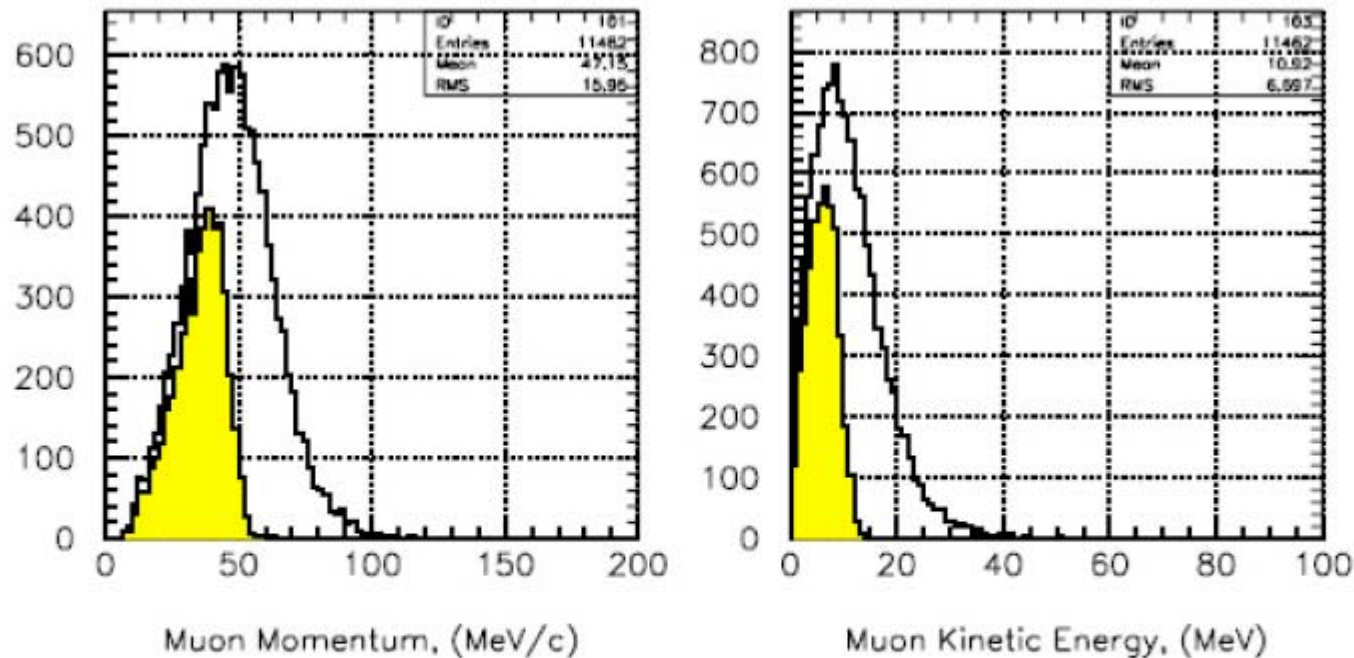
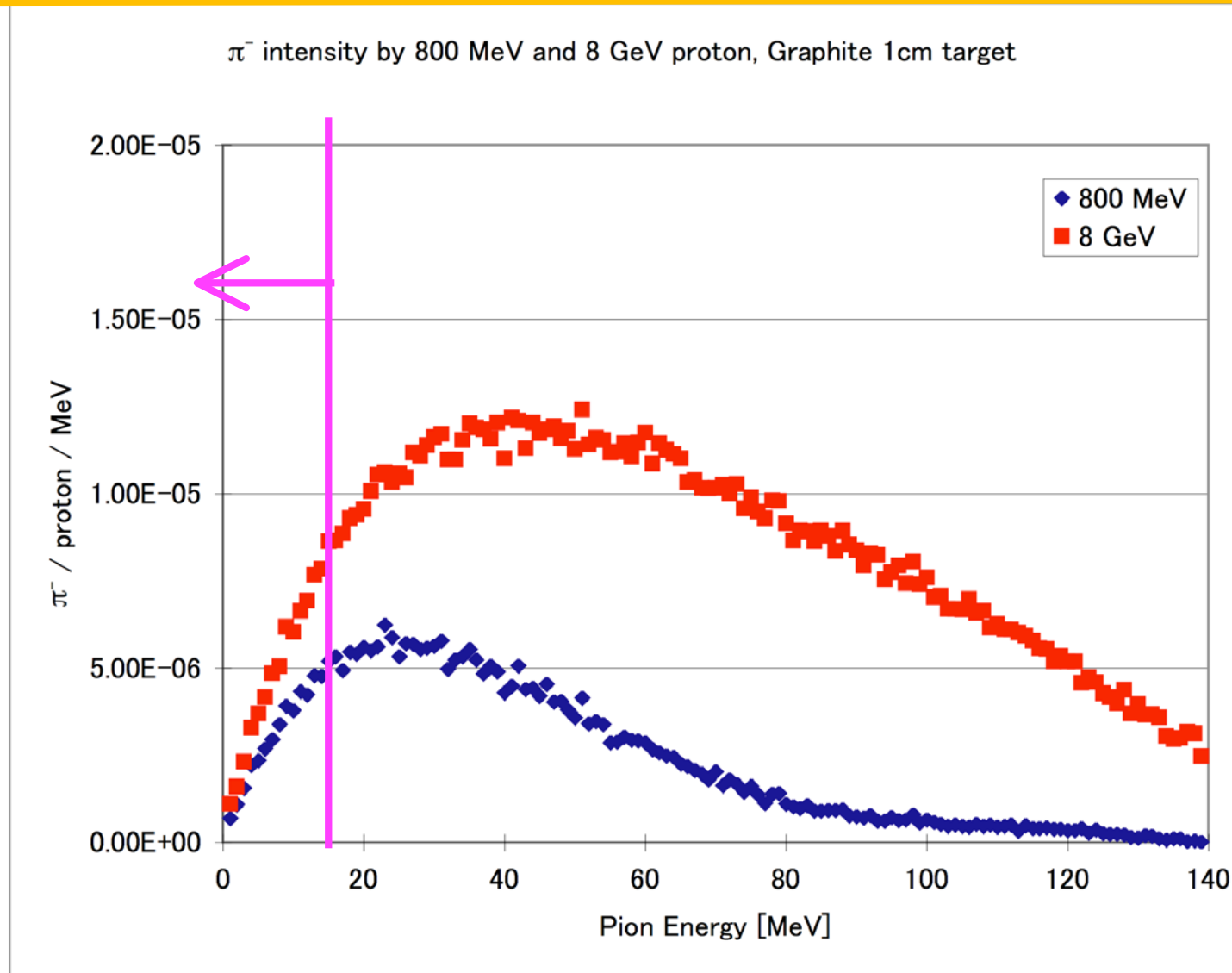


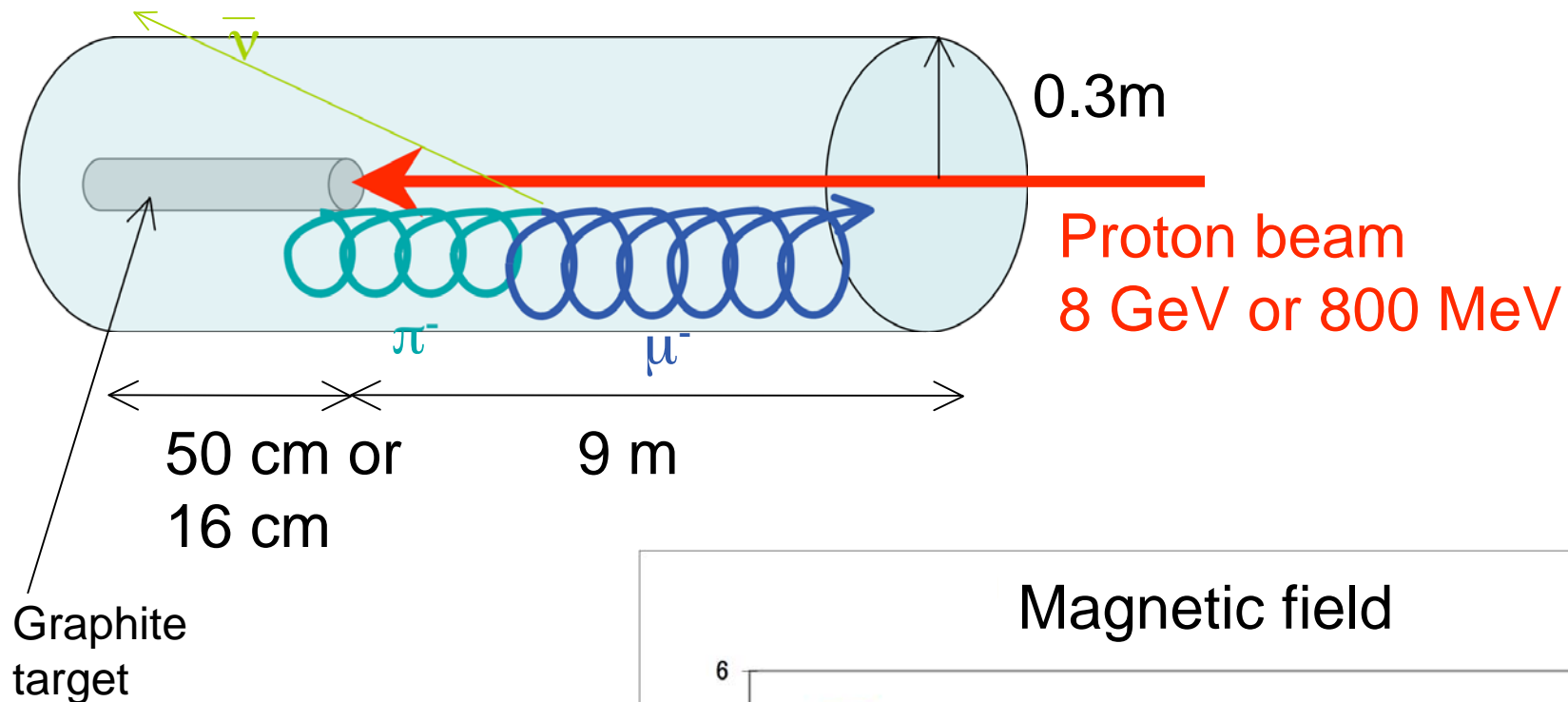
Figure 1: The muon beam momentum and kinetic energy distribution. The full curve is for all muons entering the detector solenoid and the shaded region is for those which stop in the stopping target

Pion production with a 1 cm long carbon target

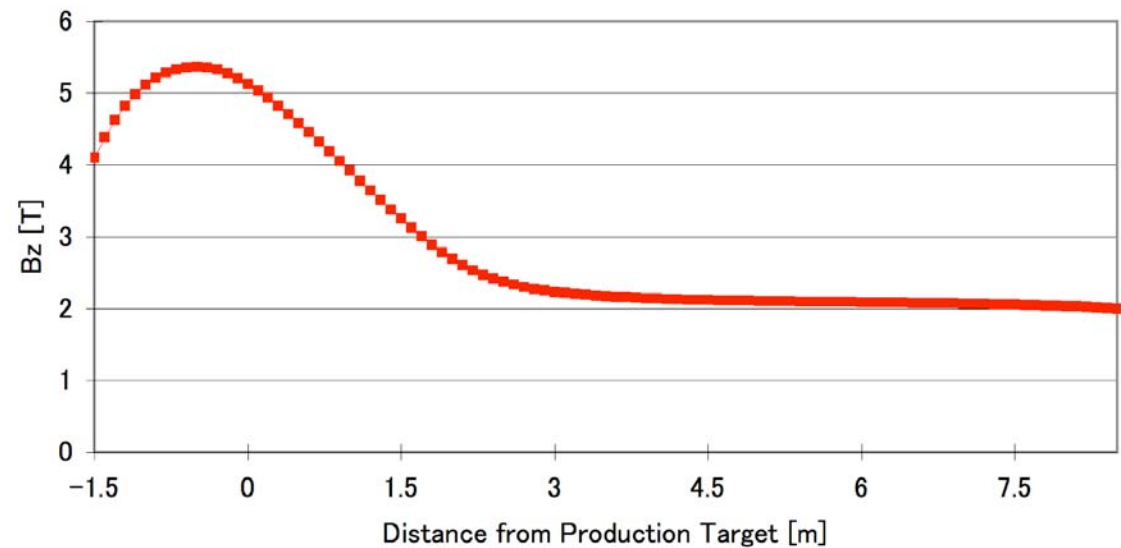


Per kW, 800 MeV protons make ~5 times more pions than 8 GeV protons at backward angles.

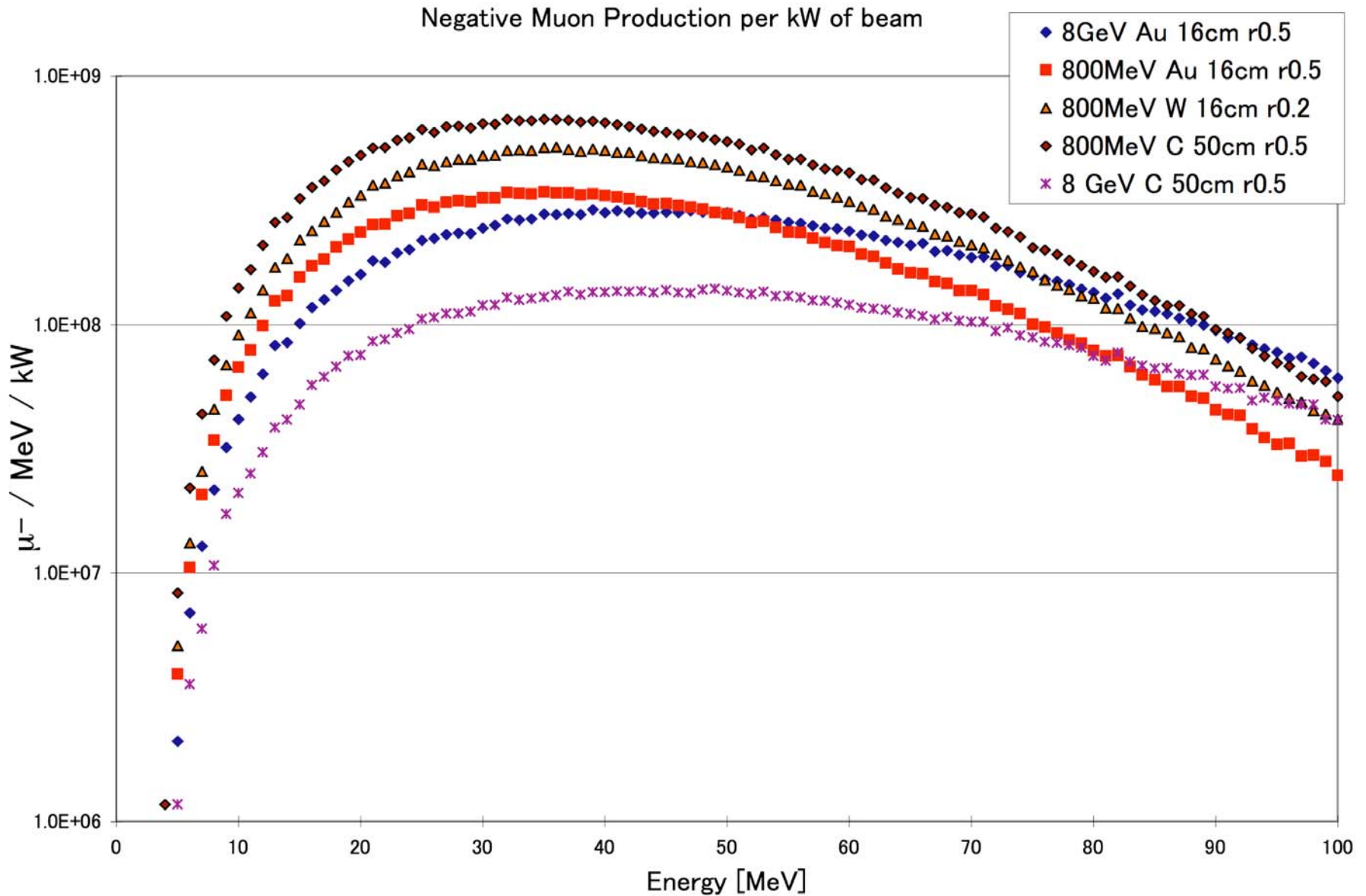
Muon intensity with 50 or 16 cm target and 9 m transport



Magnetic field



Muon intensity at 9 m: 800 MeV vs 8 GeV

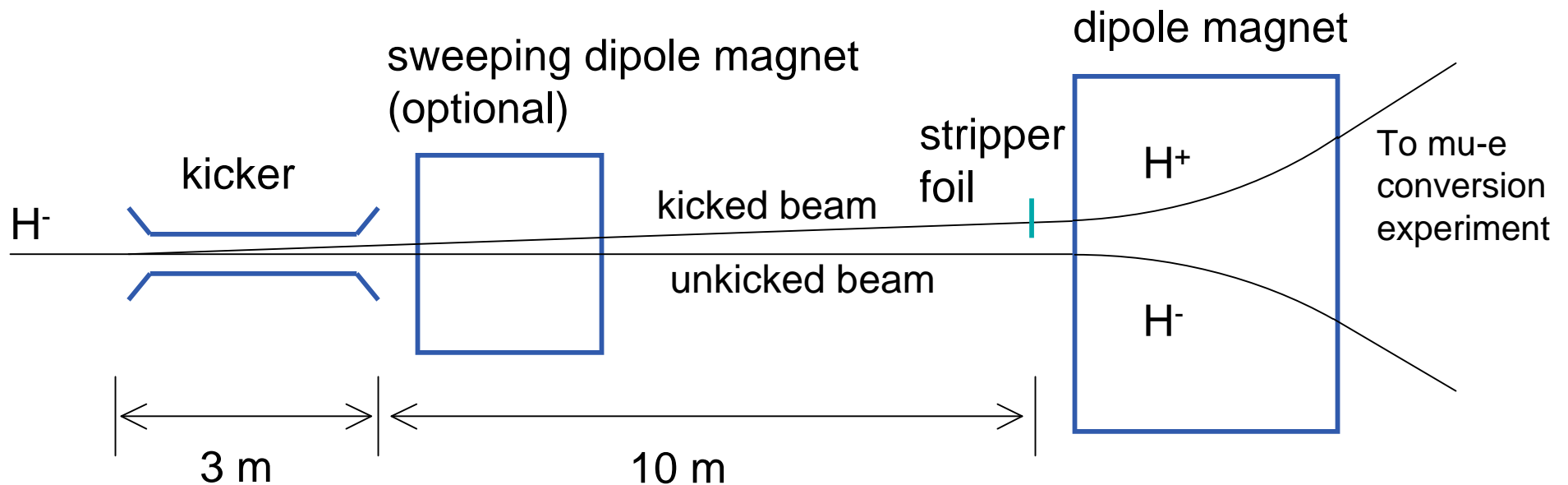
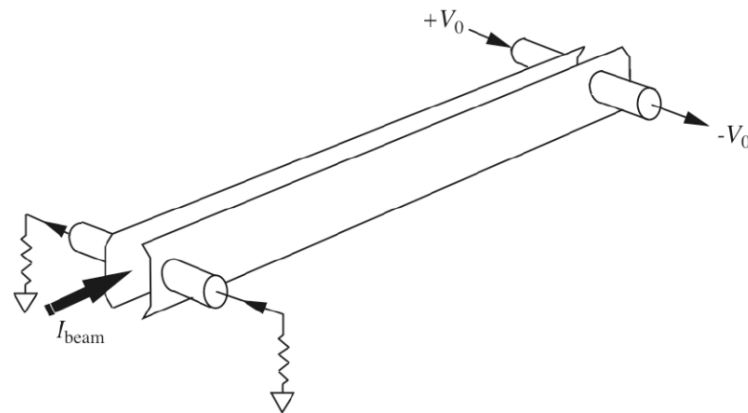


Extinction

- Will need to improve the chopper at the frontend (at 750 keV): extinction from chopper alone $\sim 10^{-4}$
- Will also need a fast cleanup kicker with high repetition-rate solid-state voltage-adder modulator to remove residual beam from the $1\mu\text{s}$ gaps. Similar modulators have been developed by Lawrence Livermore National Laboratory.
- Fast kicker is also necessary to coexist with WNR

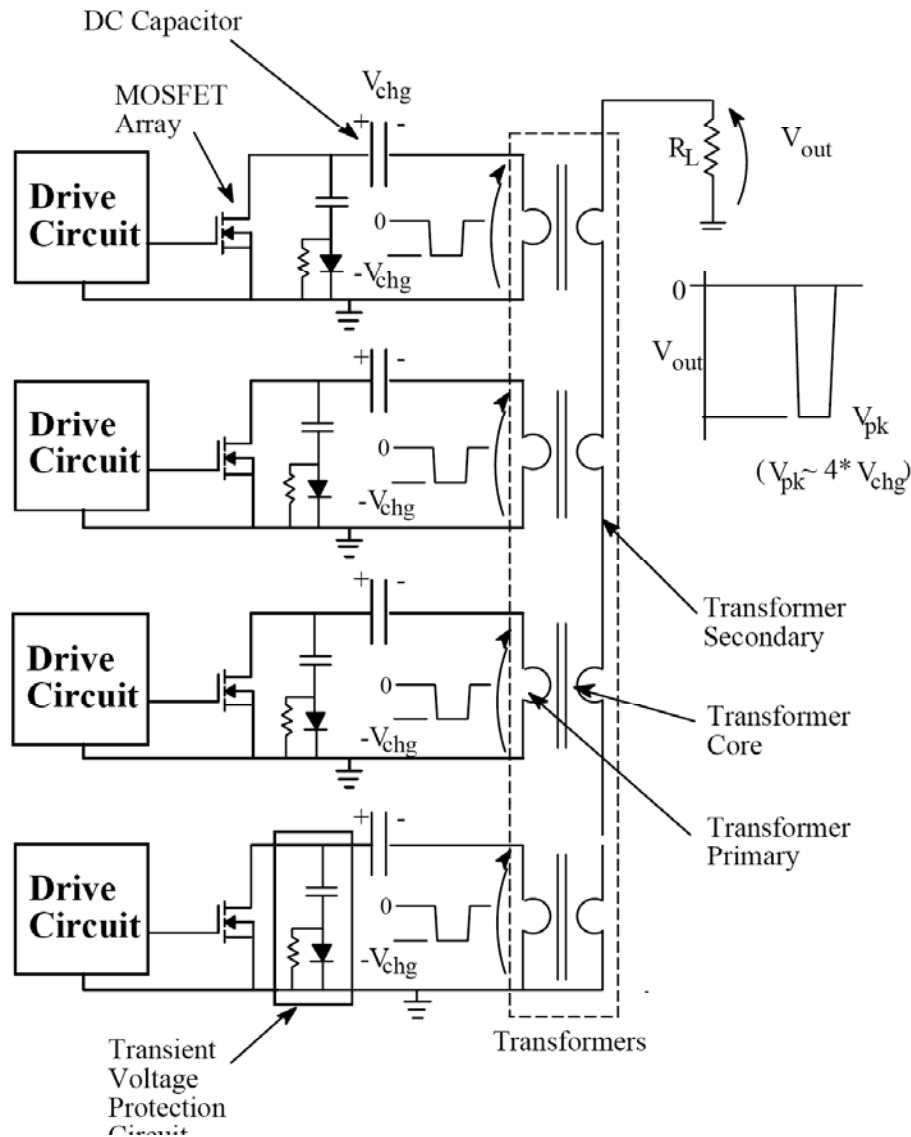
Fast kicker requirements and possible layout

Parallel plate transmission type
kicker



Beam emittance	$0.5 \pi\text{-mm-mrad}$	Beam size at kicker	2 mm	Kicker voltage	10 kV
Kick angle	2.2 mrad	Separation at 10 m	22 mm	Beam size at 10 m	3 mm

Modulator for fast kicker



Inductive voltage adder
used for DHART by
LLNL

- E.G. Cook and P. L. Walstrom, Proc. PAC 2003,p544.
- E.G. Cook et al., Proc. PAC 2005, p637.

Modulator for fast kicker

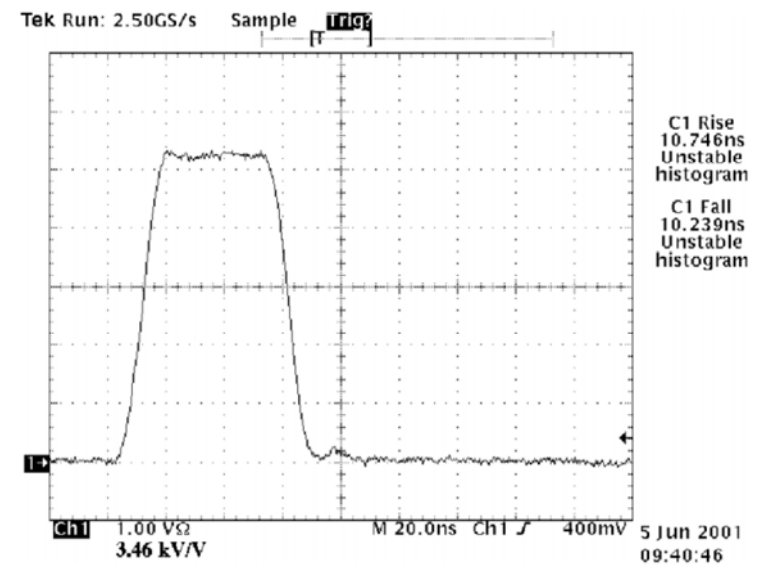
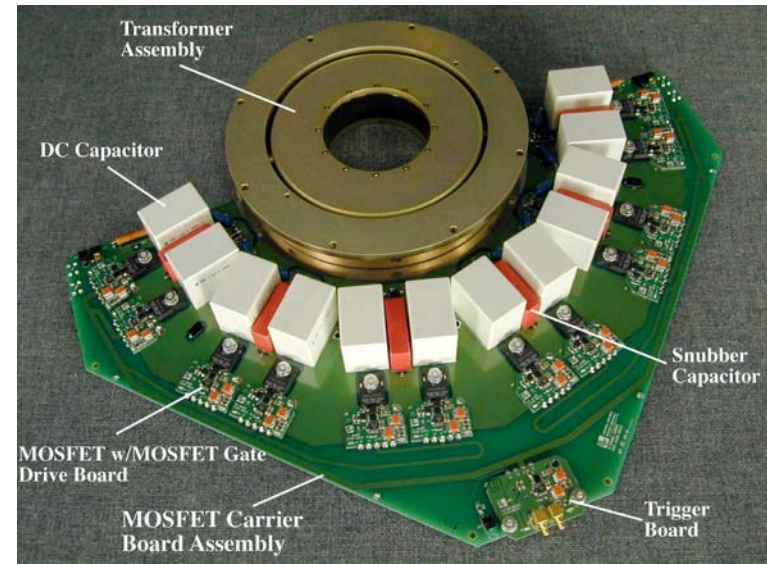


Figure 6: An 18kV Pulse of 30ns Duration

Work to be done/Concerns

- Realistic estimate of the number of stopped muons
 - Optimization of the pion production target (size, material)
 - Transport pions/muons
 - Optimization of the capture solenoid field
- Higher instantaneous rate
 - Use of the COMET type geometry (as opposed to the MECO type geometry)
- Background from the MTS target
 - Need a MC simulation study
- Beam loading: the presence of large H^- pulse in the RF cavity may cause problems
 - Possible solution: Chop H^+ macro pulses so that there will be a hole corresponding to the H^- pulse, resulting in a reduction of the beam power of 5-10% to MTS.

Possibility at MaRIE

- If the LANSCE accelerator gets upgraded to a 2 GeV, 4 MW superconducting linac, up to 200 kW will be available to the mu-e conversion experiment.
 - Another factor of 3-4 improvement
- Will need to deal with higher instantaneous detector rate
 - COMET design